CLAIMS

1. We claim a fuel cell fabricated sequentially on a single monolithic substrate to form all required operating components including fuel supply and exhaust channels, oxidizer supply and exhaust channels, ion exchange membrane, electrode catalyst, positive and negative electrodes, electrical current extractor lines, and electrical interconnect between cells.

2. We claim a fuel cell fabricated on a single monolithic substrate wherein the ion exchange process takes place predominantly in a direction perpendicular to the surface of the substrate.

3. We claim an electrolyzer fabricated sequentially on a single monolithic substrate consisting of positive and negative electrodes, electrical current supply lines, cell interconnect, electrode catalyst, ion exchange membrane, and integral hydrogen and oxygen collection channels all disposed on a single monolithic substrate.

4. The fuel cell of claim 1 wherein a crystalline material and crystallographic etch are used to simultaneously form substrate regions that provide flow channels and edge seal, and also simultaneously form beams to provide mechanical support of the membrane assembly without decreasing fuel cell active area.

5. The fuel cell of claim 1 wherein vertical interconnect provides for stacking of individual fuel cells whereby such vertical interconnects are in registration thus allowing the passage of electrical current through multiply stacked fuel cells or arrays of fuel cells.

6. The fuel cell of claim 1 wherein the substrate is patterned and etched to create flow channels and edge seals.

7. The fuel cell of claim 1 wherein plated metal is used to simultaneously form an edge seal and provide flow channels.

8. The fuel cell of claim 1 wherein an insulator layer is patterned to simultaneously form an edge seal and provide flow channels.

9. The fuel cell of claim 1 wherein a large number of options exist related to how fuel and oxidizer are introduced into the fuel cell and how they are exhausted from the cell.

10. The fuel cell of claim 1 wherein a large number of options exist related to how electrical interconnect is made to each cell.

11. The fuel cell of claim 1 wherein the surface area of the ion exchange membrane is increased in order to facilitate ion exchange and to yield higher output power density per unit area of substrate.

12. The fuel cell of claim 1 wherein ion milling is used to increase electrode surface area prior to catalyst application in order to increase current density.

13. The fuel cell of claim 1 wherein ion milling is used to increase electrode surface area prior to membrane application in order to increase current density

14. The fuel cell of claim 1 wherein ion milling is used to increase membrane surface area prior to application of catalyst or porous membrane containing catalyst in order to increase current density.

15. The fuel cell of claim 1 wherein the substrate is comprised of insulating, semi-insulating, semiconducting, or conductive material.

16. The fuel cell of claim 1 wherein singulated fuel cell elements are stacked and interconnected to form a higher output power module than would be available

from a single fuel cell element or an array of fuel cell elements on a single substrate.

17. The fuel cell of claim 1 wherein manifold supply chambers provide for stacking of individual fuel cells whereby such manifold chambers are in registration thus allowing the passage of fuel and oxidizer through multiply stacked fuel cells or arrays of fuel cells.

18. The fuel cell of claim 1 wherein a multiplicity of fuel cells fabricated on a single substrate can be singulated then stacked by hermetically bonding one to another.

19. The fuel cell of claim 1 wherein a multiplicity of single fuel cells on a single substrate are interconnected such that electrical current extractor lines are routed to the edge of a single substrate to provide connection to external devices or electrical loads.

20. The fuel cell of claim 1 wherein a monolithic semiconductor substrate contains pre-existing active semiconductor circuits for the purpose of controlling operation of the fuel cell.

21. The fuel cell of claim 1 wherein the monolithic substrate contains active MEMS type devices for controlling mechanical functions of the fuel cell.

22. The fuel cell of claim 1 wherein the fuel cell structure may be a Proton Exchange Membrane (PEMFC) type or a Solid Oxide Type (SOFC) or Solid Polymer Type (SPFC), depending on the selection of fabrication materials.

23. The fuel cell of claim 1 wherein the fuel source is comprised of alcohols, hydrogen gas, or other fuels containing redox pairs.

24. The fuel cell of claim 1 wherein the oxidizer source is air or oxygen.

25. The fuel cell of claim 1 wherein the operating temperature range may be from 70°C to 800°C depending on the type of said cell and the material system used.

26. The fuel cell of claim 1 wherein the lateral dimensions of the electrical conductors are within the range of from 0.05 micron to 1 mm for the purpose of using standard semiconductor and microfabrication manufacturing techniques.

27. The fuel cell of claim 1 wherein the electrical current extractor lines and the substrate are of high thermal conductivity for the purpose of removing heat from the active region of the fuel cell.

28. The fuel cell of claim 1 wherein multi-level electrical current extractor lines are used to increase thermal conductivity for the purpose of removing heat from the active region of the fuel cell without decreasing fuel cell active area.

29. The fuel cell of claim 1 wherein multi-level electrical current extractor lines are used for the purpose of increasing mechanical strength of the fuel cell without decreasing fuel cell active area.

30. The fuel cell of claim 1 wherein structure buildup is accomplished by methods common in the semiconductor and MEMS fabrication industry including but not limited to physical vapor deposition, chemical vapor deposition, plating, spin coating, dipping, spraying and cladding.

31. The fuel cell of claim 1 whereby structure patterning is accomplished by standard semiconductor or MEMS photomasking technique followed by etch removal or additive deposition techniques.

32. The fuel cell of claim 1 wherein masking is accomplished using standard photoresist and lithography printing techniques common in the semiconductor and MEMS fabrication industry.

33. The fuel cell of claim 1 wherein subtractive removal is accomplished using either laser ablation, stamping, ultrasonic grinding, lapping or polishing, machining, or wet or dry etching.

34. The fuel cell of claim 1 wherein subtractive feature formation is accomplished by vacuum etching processes such as sputter etching, reactive ion etching, reactive ion beam etching, deep reactive ion etching.

35. The fuel cell of claim 1 wherein anode and cathode electrical conductor lines are comprised of plated copper, gold, nickel or palladium or a combination of those.

36. The fuel cell of claim 1 wherein an inert corrosion barrier is comprised of a refractory conductor such as tantalum, tantalum nitride, titanium-tungsten nitride, or rhodium.

37. The fuel cell of claim 1 wherein an inert corrosion barrier is comprised of a patterned dielectric such as silicon nitride or silicon carbide.

38. The fuel cell of claim 1 wherein a membrane material is deposited by spin coating, spraying, dipping, or chemical vapor deposition.

39. The fuel cell of claim 1 wherein the electrode material is applied to anisotropically etched features in a membrane by physical vapor deposition, chemical vapor deposition, spin coating, dipping or doctor blading, followed by heat curing.

40. The fuel cell of claim 1 wherein metallic layers are built by plating copper, nickel, gold, or a combination thereof, for example.

41. The fuel cell of claim 1 wherein an insulating barrier layer is applied to the surface of conductive elements by vacuum deposition, physical vapor deposition, chemical vapor deposition or other conventional means for the purpose of electrically insulating one element from another or eliminating corrosion between dissimilar materials.